

Agroforestry

Agroforestry is the growing of both trees and agricultural / horticultural crops on the same piece of land. They are designed to provide tree and other crop products and at the same time protect, conserve, diversify and sustain vital economic, environmental, human and natural resources. Agroforestry differs from traditional forestry and agriculture by its focus on the interactions among components rather than just on the individual components themselves.

Research over the past 20 years has confirmed that agroforestry can be more biologically productive, more profitable, and be more sustainable than forestry or agricultural monocultures. Many other benefits have been shown. Temperate agroforestry systems are already widespread in many parts of the world and are central to production in some regions.

Success of agroforestry is largely determined by the extent to which individual forest and agricultural components can be integrated to help rather than hinder each other. The choice of tree and crop species combinations is critically important when setting up systems.

The main agroforestry types are:

- Silvopasture (Wood-pasture) - mixing trees and pasture/forage.
- Silvoarable (Wood/field crop, intercropping or alley cropping) - mixing trees and arable or horticultural crops.
- Forest farming - cultivating high-value products within forested areas.
- Forest gardening - imitating complex forest ecosystems to produce many products.
- Multi-purpose windbreaks, riparian buffer strips, contour plantings for erosion control, and fertility plantings of nitrogen-fixing trees are also options both on their own and incorporated into the three main agroforestry types.

Benefits of agroforestry

Research over the past 20 years has confirmed that agroforestry can be more biologically productive, more profitable, and be more sustainable than forestry or agricultural monocultures. Temperate agroforestry systems are already widespread in many parts of the world and are central to production in some regions.

Research has also confirmed that agroforestry systems can include the following benefits:

- They can control runoff and soil erosion, thereby reducing losses of water, soil material, organic matter and nutrients.
- They can maintain soil organic matter and biological activity at levels satisfactory for soil fertility. This depends on an adequate proportion of trees in the system - normally at least 20% crown cover of trees to maintain organic matter over systems as a whole.
- They can maintain more favourable soil physical properties than agriculture, through organic matter maintenance and the effects of tree roots.
- They can lead to more closed nutrient cycling than agriculture and hence to more efficient use of nutrients. This is true to an impressive degree for forest garden/farming systems.
- They can check the development of soil toxicities, or reduce existing toxicities - both soil acidification and salinization can be checked, and trees can be employed in the reclamation of polluted soils.
- They utilise solar energy more efficiently than monocultural systems - different height plants, leaf shapes and alignments all contribute.
- They can lead to reduced insect pests and associated diseases.
- They can be employed to reclaim eroded and degraded land.
- They can create a healthy environment - interactions from agroforestry practices can enhance the

soil, water, air, animal and human resources of the farm. Agroforestry practices may use only 5% of the farming land area yet account for over 50% of the biodiversity, improving wildlife habitat and harbouring birds and beneficial insects which feed on crop pests. Tree biodiversity adds variety to the landscape and improves aesthetics.

- They can moderate microclimates. Shelter given by trees improves yields of nearby crops and livestock. Shade in summer can be beneficial for livestock, reducing stress.
- Agroforestry can augment soil water availability to land-use systems. In dry regions, though, competition between trees and crops is a major problem.
- Nitrogen-fixing trees & shrubs can substantially increase nitrogen inputs to agroforestry systems.
- Trees can probably increase nutrient inputs to agroforestry systems by retrieval from lower soil horizons and weathering rock. ('Mining' minerals and trace elements)
- The decomposition of tree litter and prunings can substantially contribute to maintenance of soil fertility. The addition of high-quality tree prunings (ie high in Nitrogen but which decay rapidly) leads to large increases in crop yields.
- The release of nutrients from the decomposition of tree residues can be synchronised with the requirements for nutrient uptake of associated crops. While different trees and crops will all have different requirements, and there will always be some imbalance, the addition of high-quality prunings to the soil at the time of crop planting usually leads to a good degree of synchrony between nutrient release and demand.
- In the maintenance of soil fertility under agroforestry, the role of roots is at least as important as that of above-ground biomass.
- Agroforestry can provide a more diverse farm economy and stimulate the whole rural economy, leading to more stable farms and communities. Economic risks are reduced when systems produce multiple products.

Silvoarable - intercropping & alley cropping

Here, agricultural or horticultural crops are grown simultaneously with a long-term tree crop to provide annual income while the tree crop matures. Trees are grown in rows with wide alleys in-between for cultivating crops.

Alley component: Any arable or horticultural crop is possible. Overwintering crops (ie autumn-sown) are very efficient users of the almost full light available over the dormant season of deciduous trees, and may be the best choices for narrow alleys where trees are quite large. It is important that the alleys are physically cultivated (or at least ripped with deep tines) - horticultural no-dig raised beds are likely to fill with fine tree roots.

Tree component: may be timber or fuelwood trees, or a fruit or nut crop. Pollards and coppiced trees are both possible, the former interfering least with arable operations.

Fruit crops can be used as the tree component. Apples, cider apples and plums are all possibilities.

Nut crops can include walnuts, chestnuts and hazelnuts.

Forest farming

In forest farming, high-value speciality crops are cultivated under the protection of a forest canopy that has been modified and managed to provide the appropriate conditions. It is a way of utilising forests for short-term income while high-quality trees are being grown for wood products. The amount of light in the stands is altered by thinning, pruning, or adding trees; 5-40% crown cover is usually desirable. Existing

stands of trees can be intercropped with annual, perennial, or woody plants.

Five main categories of speciality crops are:

FOODS:

- mushrooms, eg. Shiitake, matsuki (grown on logs, in sawdust/chipped wood beds etc.)
- nuts, eg. hazelnuts, small chestnut species; note that the canopy trees could also be nut producers, eg. walnuts, chestnuts, pecans, pine nuts
- vegetables, eg. radish, beetroot, Swiss chard
- honey from bee plants, eg. plum, black locust
- herbs, eg. mints
- fruits, eg. blueberries, elderberries, blackberries, raspberries, strawberries, currants, gooseberries
- edible flowers, eg. elderflowers
- sap products - eg. maple syrup, birch sap wine etc.

Silvopasture

These systems comprise trees deliberately introduced into a forage production system (or, rarely, forage introduced into a tree production system), the whole designed to produce a high-value tree component, while continuing to produce the forage and livestock component indefinitely or for a significant time.

Forage system: usually permanent pasture, grazed rotationally. Other options are pasture cut for hay or silage. White clover (especially wild types) is more shade-tolerant than other pasture legumes and should be included in mixtures. Browsing animals are more likely to damage trees than large grazing animals or poultry. Deciduous trees are more readily browsed than conifers.

Tree component: may be timber or fuelwood trees, or a fruit or nut crop. Nitrogen-fixing trees can also be used to supply nitrogen for the forage crop. Trees are grown as standards or as pollards.

Fruit crops as the tree component are usually grown as standards to allow for grazing beneath. Apples, cider apples and plums are some of the possibilities.

Nut crops can include chestnuts and hazelnuts. Walnuts are slow growing and are only suitable if animals are excluded or if a cheap form of tree protection is available.

Design & establishment

Trees can be planted evenly at wide spacing (eg. 10 x 10 m), in rows with forage alleys (of 10-30 m width) between, or in clusters. All methods necessitate some form of weed control - black plastic mulches produce the best tree growth.

Forest gardening

A forest garden is a designed agronomic system based on trees, shrubs and perennial plants. These are mixed in such a way as to mimic the structure of a natural forest - the most stable and sustainable type of ecosystem in this climate.

The primary aims for the system are:

- to be biologically sustainable, able to cope with disturbances such as climate change
- it should be productive, yielding a number (often large) of different products
- it should require low maintenance.

The crops which are produced will often include fruits, nuts, edible leaves, spices, medicinal plant products,

poles, fibres for tying, basketry materials, honey, fuelwood, fodder, mulches, game, sap products.

Forest gardens (often called home gardens) have been used for millennia in tropical regions, where they still often form a major part of the food producing systems which people rely on, even if they work elsewhere for much of the time. They may also provide useful sources of extra income. Their use is intimately linked with prevailing socio-economic conditions. They are usually small in area, often 0.1-1 hectares (0.25-2.5 acres).

In temperate regions, forest gardens are a more recent innovation, many inspired by Robert Hart's efforts in Shropshire (UK) over the last 30 years. A major limiting factor for temperate forest gardens is the amount of sunlight available to the lower layers of the garden: in tropical regions, the strong light conditions allow even understorey layers to receive substantial light, whereas in temperate regions this is not usually the case. To compensate for this, understorey layers in temperate forest gardens must be chosen very carefully - there are plenty of plant crops which tolerate shady conditions, but many are not well known. Many of the more common shrub or perennial crops need bright conditions, and it may be necessary to design in more open clearings or glades for such species.

Temperate forest gardens are also usually small in area, from tiny back garden areas up to a hectare (2.5 acres) in size. While food production and land use remain the concern of a minority of landowners and businesses, their use is likely to be limited to 'alternative' and organic gardeners and land users.

The key features which contribute to the stability and self-sustaining nature of this system are:

- the large number of species used, giving great diversity
- the careful inclusion of plants which increase fertility, such as nitrogen fixers (eg. Alders [*Alnus* spp], Broom [*Cytisus scoparius*], *Elaeagnus* spp, and shrub lupins [*Lupinus arboreus*]).
- the use of dynamic accumulators - deep rooting plants which can tap mineral sources deep in the subsoil and raise them into the topsoil layer where they become available to other plants, eg. Coltsfoot [*Petasites* spp], Comfrets [*Symphytum* spp], Liquorice [*Glycyrrhiza* spp], Sorrel (and docks!) [*Rumex* spp].
- the use of plants specially chosen for their ability to attract predators of common pests, eg umbellifers like tansy.
- the use, where possible, of pest and disease resistant varieties, eg. apples.
- the increasing role of tree cover and leaf litter which improve nutrient cycling and drought resistance.

A forest garden is organised in up to seven 'layers'. Within these, the positioning of species depends on many variables, including their requirements for shelter, light, moisture, good/bad companions, mineral requirements, pollination, pest-protection, etc. The layers consist of:

- Canopy trees - the highest layer of trees. May include species such as Chestnuts [*Castanea* spp], Persimmons [*Diospyros virginiana*], honey locusts [*Gleditsia triacanthos*], Strawberry trees [*Arbutus* spp], Siberian pea trees [*Caragana arborescens*] Cornelian cherries [*Cornus mas*], Azaleds and other hawthorn family fruits [*Crataegus* spp], Quinces [*Cydonia oblonga*], Apples [*Malus* spp], Medlars [*Mespilus germanica*], Mulberries [*Morus* spp], Plums [*Prunus domestica*], Pears [*Pyrus communis*], highbush cranberries [*Viburnum trilobum*].
- Small trees and large shrubs, mostly planted between and below the canopy trees. May include some of the canopy species on dwarfing rootstocks, and others such as various bamboos, Serviceberries [*Amelanchier* spp], Plum yews [*Cephalotaxus* spp], Chinkapins [*Castanea pumila*], *Elaeagnus* spp, and Japanese peppers [*Zanthoxylum* spp]. Others may be trees which will be coppiced to keep them shrubby, like medicinal *Eucalyptus* spp, and beech [*Fagus sylvatica*] and limes [*Tilia* spp] with edible leaves.
- Shrubs, mostly quite shade tolerant. May include common species like currants [*Ribes* spp] and berries [*Rubus* spp], plus others like chokeberries [*Aronia* spp], barberries [*Berberis* spp], Chinese dogwood [*Cornus kousa chinensis*], Oregon grapes [*Mahonia* spp], New Zealand flax

[*Phormium tenax*] and Japanese bitter oranges [*Poncirus trifoliata*].

- Herbaceous perennials, several of which are herbs and will also contribute to the ground cover layer by self-seeding or spreading. These may include Bellflowers with edible leaves [*Campanula* spp], Comfrets [*Symphytum* spp], Balm [*Melissa officinalis*], Mints [*Mentha* spp], Sage [*Salvia officinalis*], and Tansy [*Tanacetum vulgare*].
- Ground covers, mostly creeping carpeting plants which will form a living mulch for the 'forest floor'. Some may be herbaceous perennials (see above), others include wild gingers [*Asarum* spp], cornels [*Cornus canadensis*], *Gaultheria* spp, and carpeting brambles (eg. *Rubus calycinoides* & *R. tricolor*).
- Climbers and vines. These are generally late additions to the garden, since they obviously need sturdy trees to climb up. They may include hardy kiwis [*Actinidia* spp], and grapes [*Vitis* spp].
- The final 'layer' is the root zone or rhizosphere. Any design should take account of different rooting habits and requirements of different species, even if root crops are not grown much. Some perennials with useful roots include liquorice [*Glycyrrhiza* spp] and the barberries [*Berberis* spp] whose roots furnish a good dye and medicinal products. Various beneficial fungi can also be introduced into this layer.

BENEFITS:

- A long-term biologically sustainable system for growing food & other products for a household
- Once established, little work is needed to maintain

DRAWBACKS:

- Planting out and establishment usually requires large numbers of plants and substantial work

Other agroforestry types:

Riparian buffer strips are natural or re-established streamside forests made up of tree, shrub and grass plantings; they buffer pollution of waterways from adjacent land, reduce bank erosion, protect aquatic environments and enhance wildlife value.

Contour buffer strips are basically rows of trees (and sometimes shrubs) in rows along contours, with alleys between for forage or alley cropping. The aim is to reduce soil erosion on slopes and give some wind protection.

Fertility plantings are plantings of trees and/or shrubs with the main aim of improving nutrient input and/or cycling for a forage or alley crop. Nitrogen-fixing trees and shrubs are usually used, for example Italian alder, *Elaeagnus*, Sea buckthorn, and Black locust. Nitrogen fixed by bacteria in association with their roots is made available to other crops via leaf fall, rain drip, root-root contact and beneficial fungi. The amounts made available are in the same order as from perennial legumes.

Field windbreaks protect a variety of wind-sensitive row, cereal, vegetable, orchard and vine crops, resulting in up to 25% increases in production; and also control wind erosion, and increase bee pollination. Livestock windbreaks help reduce animal stress and mortality, and reduce feed consumption; weight gains of up to 10% and milk production increases of 8-20% can result. Farm homes in windy areas protected by windbreaks can expect heating costs to be cut by as much as 30%.

Windbreak spacing depends on windbreak height (H), soil erodibility, crop sensitivity & rotation, and climate.

Policy Considerations

The Eu has recently taken a historic step to legitimise the practice of agroforestry through its recognition

under pillar 1. At a Pillar 2 level article 23 has been passed that will provide funding for the planting of agroforestry and its maintenance for upto 5 years. The UK government could make the most of this progressive legislation by taking up the directive and implementing it through support for UK farmers practicing agroforestry.

Until recently the CAP has had no recognition of agroforestry as a form of land use. 'Forestry' and 'agriculture' have been sealed off from each other in an artificial division; any holding having more than 50 trees being unclassifiable as a farm. The recognition of agroforestry as a legitimate, productive and sustainable form of land use is something that should be welcomed from Europe.

Agroforestry has great potential to create economically productive and environmentally sustainable farms. The basic premise of the model is simple and provable: Arable crops, typically harvested in August/September fail to maximise on the solar energy available through autumn. As such, the addition of trees to an arable farm increases the potential for capture and storage of solar energy in the form of fruit, nuts and timber. As such, the potential economic benefits to farmers in the UK are significant. With the additional harvests afforded by an agroforestry set up, UK farmers could well be benefiting from the sale of a greater range of products over a longer period of the year.

The environmental benefits that come through integrating crops with trees are also significant. Trees create habitats which increase biodiversity both above and below ground. The support that tree roots lend to agricultural soils reduce erosion, soil run off and nutrient and water loss. It has been demonstrated that up to 50% less nitrogen is lost from agroforestry holdings as compared to conventional arable holdings.

A working case study of such land use is to be found in China, where the research and development of agroforestry are now over forty years old. The result is a profusion of productive agroforestry holdings providing food and building materials for Chinese communities. In Henan Province alone there are 3.2 million hectares of integrated wheat and timber agroforestry. This is an example to be followed by all governments with an interest in resilient and productive land use. To bring it closer to home, both the Welsh and Scottish governments have embraced the new EU directive on agroforestry.